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Development and Morphology of Falling Dunes, Northeast Kuwait

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Introduction

The interaction of topography with sand–laden winds is responsible for the development of different forms of aeolian landforms. In the literature, these types of aeolian landforms have different terminology, being termed "sand shadow" or "sand drifts" by Bagnold (1941), "fixed" dunes" by Howard (1985) and Recently, "topographically anchored sand dunes" by Cooke et al. (1993) and topographical controlled sand dune by Lancaster and Tchakerian (1996).

In Kuwait, the continually transported sand across the surface under the influence of the prevailing northwesterly wind, result in the formation of different aeolian landforms including falling dunes that are the most common features in the northeast of the country.

The main objective of this study is to identify factors controlling the development and distribution of the falling dunes in Kuwait with emphasis on the influence of the topography on the morphology and the size of these dunes.

Methods

Aerial photographs of 1992, (scale 1:29000), and SPOT image of 1995 (scale 1: 100000) were analyzed to identify the distribution of the falling dunes along the escarpment and presented on a map of scale 1:50000.

The morphometric characteristic of selected falling dunes was identified using total station theodlite, where measurements of the dimensions of the dissecting wadis was through aerial photos study.

Results

Distribution of Falling Dunes

Falling dunes are the most common aeolian landforms in the northeast of Kuwait. They are associated with Al-Atraff, Al-Mutla, and Jal Az-Zor escarpment and occur at the northwestern corner of Umm Al-Rimmam Depression. Based on the aerial photographs mapping, there are four principal zones of falling dunes that can be distinguished along the escarpment of the study area. They are located downwind of regional aeolian sand pathways trending in a northwest – southeast direction with variable length and width. Their alignment is related mainly to microtopographical control and the prevailing northwesterly wind.

Falling Dune Morphometry

The falling dunes vary considerably in size. The length of the falling dunes along the escarpment ranges from 38 to 383 m and the width from 7 to 85 m, while they attain a maximum height of 12m. Despite of the importance of the continuos supply of sand, this range of falling dunes size is controlled chiefly by combination of the height of the cliff and in part the size of the wadis, where the falling dunes mostly confined (Fig. 1 & 2).

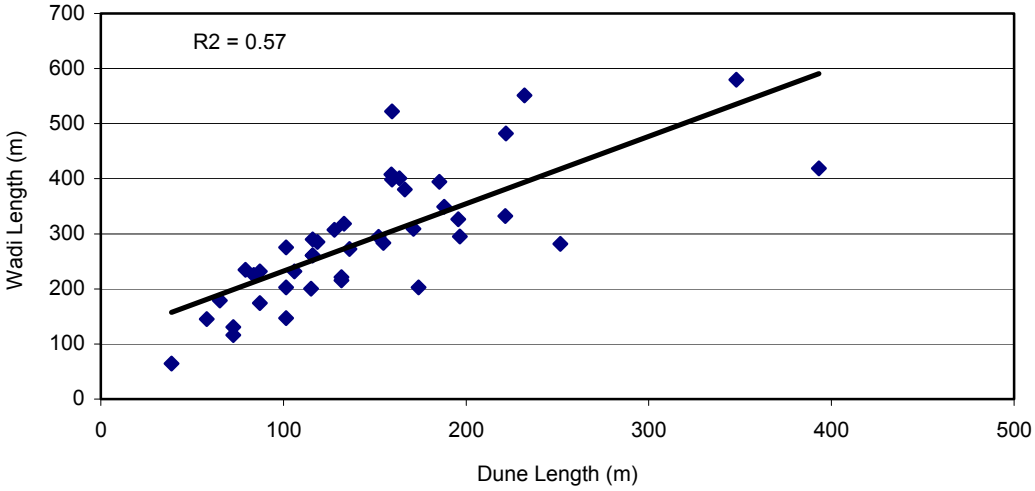

Figure 1. Correlation between length of falling dunes and wadis along escarpment.

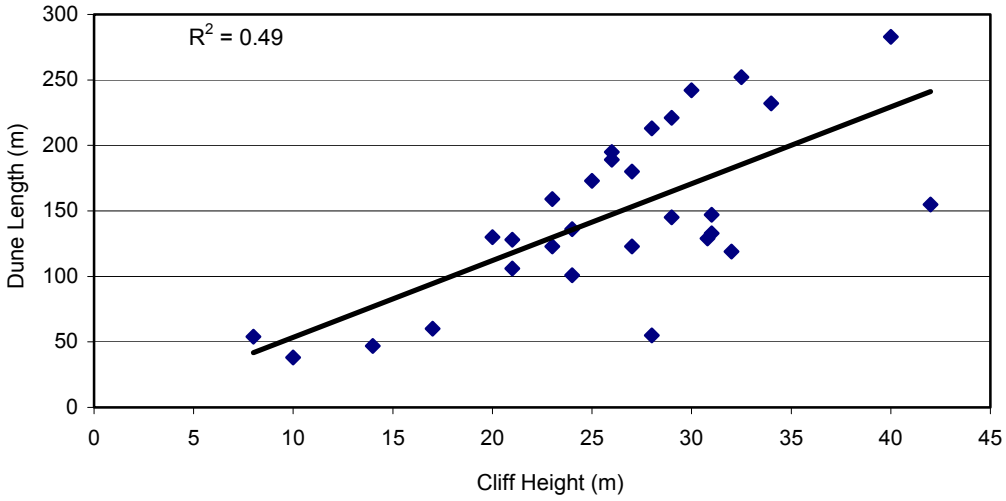

Figure 2. Bivariate plots of cliff height Vs length of the falling dunes.

Falling dune morphology

Most falling dunes along the escarpment accumulate in a simple form, existing as a single finger like deposit oriented in the NW-SE direction. Within this general form, there is slight morphological variation. This variability can be explained by the factors related to the changes of the hilly terrain morphology (Fig. 3). There are three major geomorphologic association between topography and morphology of the falling dunes. These are: falling dune attached to cliff headland; (2) falling dunes confined within wadis of different orientations;

(3) falling dunes blocked by an isolated hill downwind of the escarpment.

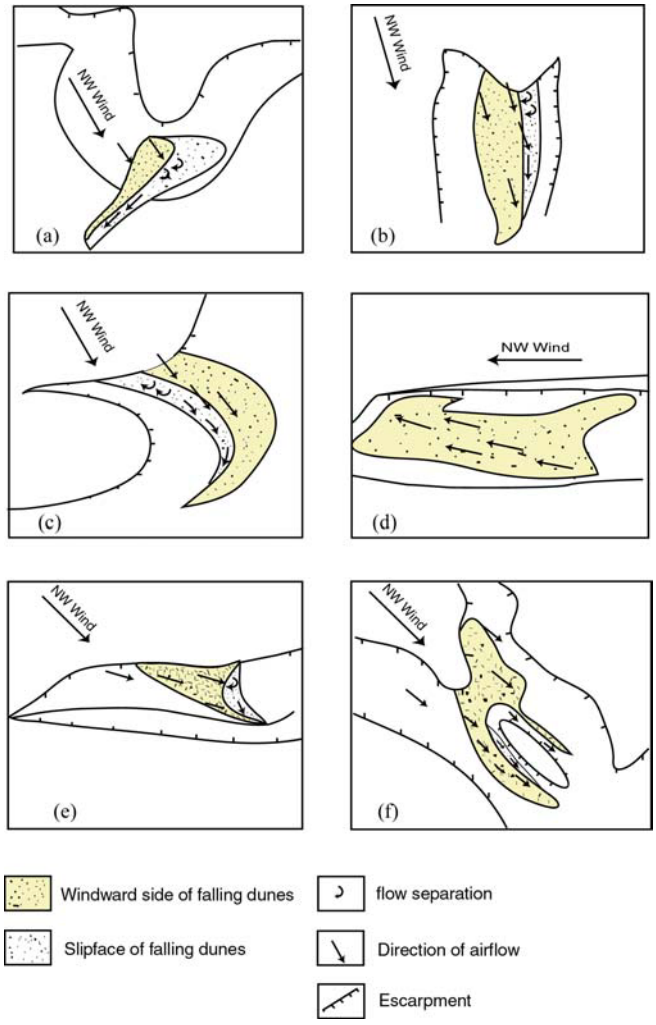

Figure 3. Different forms of falling dunes related to the effect of topography with emphasis on the airflow over the escarpment. (a) falling dunes with sinuous crest attached to cliff headland outside of a wadi. (b) falling dunes with straight slipface attached to headland close to the side of a wadi. (c) falling dune with curved slipface attached to headland close to the side of a wadi. (d) falling dunes without linear pattern located within wadi oriented parallel to the sand-laden wind and accumulated at the side wall of the wadi. (e) crescent-like falling dune within wadi oriented at angle to the sand-laden wind. (f) diverted falling dune around isolated hill down wind of the cliff headland.

Discussion

Development of Falling Dunes

The comparison of aerial photographs of 1972 and 1992, indicates the recent development of these dunes along the escarpment. This changes in a relatively short time period was chiefly as result of a combination of climatic conditions and increased availability of source by human activity under favorable topographic and aerodynamic conditions.

Climatic Conditions

The wind regime and rainfall are the most important climatic elements that influence

dune development in Kuwait. Aeolian processes were highly active during a dry period from 1981 to 1992. In that period the rainfall was irregular and below the average (110 mm/year). Strong prevailing northwesterly winds during this drought period exerted further influence in activating aeolian processes in Kuwait. This almost unidirectional nature of the effective wind in Kuwait is important in the development of falling dunes since they can not survive where there is a large variation in wind direction (Bagnold, 1941; & Cooke et al, 1993).

Human Activities

The development of falling dunes in Kuwait accompanied the drought period from 1981 to 1992, when the aeolian processes were highly active and the supply of sand was plentiful as result of land misuse by human activities including overgrazing, off-road traffic, desert camping and gravel quarrying. In addition, the 2nd Gulf War and it consequences accelerated the development of falling dunes through destruction of vegetation cover and natural surface sediment armor.

Topography

Falling dune in Kuwait developed as result of interaction of the prevailing northwesterly wind with Jal Az-Zor escarpment. Their development significantly effected by the orientation and slope angle of the escarpment. It can be observed that well developed falling dunes associate mainly with steep sided escarpment and there was no falling dunes were developed along the escarpment with gentle slope (less than 30^{o})

Along Jal Az-Zor escarpment most of the falling dune accumulate in the zone where the escarpment oriented normal to the prevailing northwesterly. However at the far northeast of the study area the escarpment swing to southeast direction running parallel to the prevailing wind there were no falling dunes developed except at Ras Al-Subiyah where the escarpment oriented slightly at angle with the prevailing wind.

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